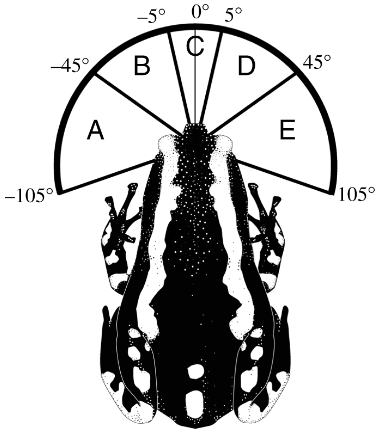
Inside JEB is a twice monthly feature, which highlights the key developments in the *Journal of Experimental Biology*. Written by science journalists, the short reports give the inside view of the science in JEB.

Inside JEB

FROG’S TONGUE TWISTER



When Stephen Deban saw his first *Phrynomantis bifasciatus* frog, he knew he was looking at something truly bizarre. The petite red and black frog seemed able to fling its tongue in almost any direction, even trapping insects that had wandered onto it’s forelegs. This was completely unexpected. Most frogs only aim their tongues in one direction; straight forward. Somehow the tiny anuran had developed the frog equivalent of manual dexterity. But how *Phrynomantis* controls its agile tongue wasn’t clear. Most frogs simply flip the tongue out, yet *Phrynomantis* was definitely doing something different; but what? Kiisa Nishikawa decided to put the amphibian through its feeding paces. Working with Jay Meyers, James O’Reilly and Jenna Monroy, the team probed the tongue’s inner workings to get to the bottom of the frog’s unorthodox feeding habits (p. 21).

By mammalian standards, frogs’ tongues aren’t particularly versatile, in fact they’re backwards. Connected at the front of the jaw, the tongue points backwards in the mouth, so when a frog spots a tasty morsel, it’s simply a matter of snapping the mouth open so that the front-attached tongue rolls out and flips forwards. Meyers explains that for most frogs, this is an uncontrolled ballistic movement. But watching *Phrynomantises* deviations from the straight and narrow, it was clear to Meyers that the sideways flick was a controlled, muscular movement.

Teaming up, Meyers and O’Reilly came up with three possible scenarios for the tongue’s deviations. Either the animal’s jaw flexed as it opened, so that it threw the tongue to one side, or a muscle on one side of the tongue contracted, pulling the tongue in that direction. The third possibility was that the animal controlled its tongue hydrostatically. Meyers explains that when a hydrostatic muscle contracts, its volume doesn’t change. So if a muscle is constrained by connective tissue, then a contraction in one direction will cause the muscle to extend in another. Meyers figured that the frog’s mobile tongue could be guided hydrostatically so that a contracting muscle on one side would cause that side of the tongue to lengthen, and push the outside edge of the tongue so that it turns away from the contracting side.

Knowing that they could identify the tongue twister by temporarily disconnecting the nerves to various muscles, and then testing the frog’s aim, the team set about tempting the animals with termite snacks. First they disconnected the jaw bending muscles on one side to see whether they affected that frog’s aim. But its accuracy was unaffected, so the team began focusing on the muscles in the tongue. They disconnected the nerve that controls all of the tongue’s flipping muscles on one side, and set the frogs the same termite-trapping task.

Meyers and O’Reilly reasoned that if the tongue was controlled by a contraction that pulled it in the direction of the contracting muscle, then a frog that had lost the use of muscles on that side could only direct its tongue in the opposite direction. But if the tongue was directed hydrostatically, then it could trap termites on the disconnected muscle’s side, and not the other.

Challenging the animals to catch termite treats placed on either side, Meyer’s patience was rewarded; the frogs captured termites on the same side as the inactive muscles. The tongue was hydrostatically directed. And when the team looked at the muscle structures in the tongue, there were the telltail signs of a hydrostatic muscle, pushing, not pulling, the tongue in the right direction.

10.1242/jeb.00779

Meyers, J. J., O’Reilly, J. C., Monroy, J. A. and Nishikawa, K. C. (2004). Mechanism of tongue protraction in microhylid frogs. *J. Exp. Biol.* **207**, 21-31.

SIZZLING SQUIRREL’S AMAZING MUSCLES

When it’s too hot for lizards, you know its really sizzling. But this didn’t stop Mark Wooden heading out into the Sonoran Desert when the mercury hit 50°C. Frying alive in the mid-day sun, Wooden realised that everything had gone to ground, except for the round-tailed ground squirrels; ‘they were all over the place’ he remembers. But how could the diminutive mammals keep functioning in the gruelling conditions? Looking at the their body temperature, Wooden realised that the small creatures had gone heterothermic,

regulating their temperature over an enormous range; some even went up to 42°C! But this unorthodox lifestyle must surely come at a cost Wooden thought, or why would the rest of us bother stoking the fire and cooling the flames to stick at a comfortable 37°C? Bundling up a few of the small rodents, Wooden headed home to see if he could find what the squirrels had traded in for heterothermy (p. 41).

Safe back in Glenn Walsberg's lab in Tempe, Wooden's biggest problem was keeping the ground squirrels slim! Even on as little as 2 g of food a day, the rodents grew tubby. Wooden suspects that the animal's natural diet is so restricted that it has driven them to heterothermy. He thinks that a homeothermic lifestyle is simply too extravagant for the desert's slim pickings. But as heterothermy is clearly beneficial for the majority of mammals, the desert squirrel must have compensated for the loss by cutting back somewhere else. Knowing that locomotion is one of the first faculties to fail when a homeotherm's temperature fluctuates, Wooden decided to test how the squirrels' muscles fared as their body temperature rose and fell.

Startling the rodents with a hissing sound, Wooden filmed the animals as they scampered for safety along an exercise track. Measuring their speed and the rate that their little legs scuttled along, Wooden was astonished that the animals didn't slow, even when their body temperature plummeted to 30°C or rocketed to 40°C! And when he tested their weightlifting capacity, they all managed to lift 1.3 times their own body weight, no matter what their body temperature.

What was going on? Most muscles only work well at one temperature, but these animals weren't paying attention to those rules. There must be something different about their muscles that protects them from the devastating effects of temperature variations. Wooden is beginning to look closer at the muscles' neurofunction. Although he doesn't know whether their neurons function well over a wide temperature range, when he tested their function in the lab, the squirrels muscles somehow defied logic, functioning as well at 15°C as they did at 37°C!

Getting back to Wooden's first question though is still problematic; why are most mammals homeothermic, when the round-tailed squirrel seems perfectly content without? Wooden is optimistic that by identifying the unique adaptations that permit the rodent's heterothermic life-style, he could identify the crucial factor that made the rest of us select homeothermy. Mean while, Nöel Cowards's classic might need rewriting, 'cause there's no sign of ground squirrels getting out of the mid-day sun!

10.1242/jeb.00781

Wooden, K. M. and Walsberg, G. E. (2004). Body temperature and locomotor capacity in a heterothermic rodent. *J. Exp. Biol.* **207**, 41-46.

FLYING INTO A HEAD WIND

Listening to Mark Frye talk, you might think he's passionate about jet flight. But listen closer. Frye's not discussing the latest developments in high performance aeronautics, he's describing a much more diminutive aviator; the fruit fly. Fascinated by the neural coordination of complex behaviours, Frye, Michael Dickinson and Lance Tammero have focused on the fly because its extreme performance makes it easier to relate complex neural controls to the behaviours they regulate. Tammero and Frye have turned their attention on the visual reflexes that protect flies from crashing into objects as they cruise around. By watching flies' responses in a flight arena as they flew freely, Tammero realised that the flies turned to avoid images that expanded, in much the same way as objects loom during an approach. But was that the whole story? Tammero began interfering with the insects' visual world to untangle how expanding images trigger the flies' about face (p. 113).

First Tammero needed to be able to control the flies' visual world, so he tethered the insects in Dickinson's high-tech fly-flight arena, where he could control moving LED patterns inside the cylinder to simulate the world's movements around the insects as they 'flew'. He also recorded the stationary flies' reactions to their environment by tracking their wing beats. 'It's a bit like a fly video game' says Frye. Secured inside the arena, Tammero convinced the tethered flies that the world was spinning around them, by making the LED patterns circulate towards the left; the insects made leisurely turning wing beats. Then he played the flies a highspeed translation sequence that moved from right to left; the flies beat their wings to dodge out of the way and avoid the expanding image appearing on one side. But how could the flies tell both movements apart when both movements' front views moved leftwards? Tammero divided the flies visual world in two; half infront and half behind, so that he could control each view independently to see how the insects reacted to the separate visual hemispheres.

Tammero was in for a shock. The tethered flies seemed to be taking their visual cues from the view behind! This was completely unexpected. Why would flies depend more on the backward view to tell them which way to turn? Frye explains that it's the rear view that tells the speeding insects whether they are on a collision course with an expanding image or simply turning around. If the rear image moves in the same direction as the front view, then flies know they are heading for a crash and need to turn quickly. But if the front and rear views move in opposite directions, then they are taking a leisurely spin, and there's no collision to avoid.

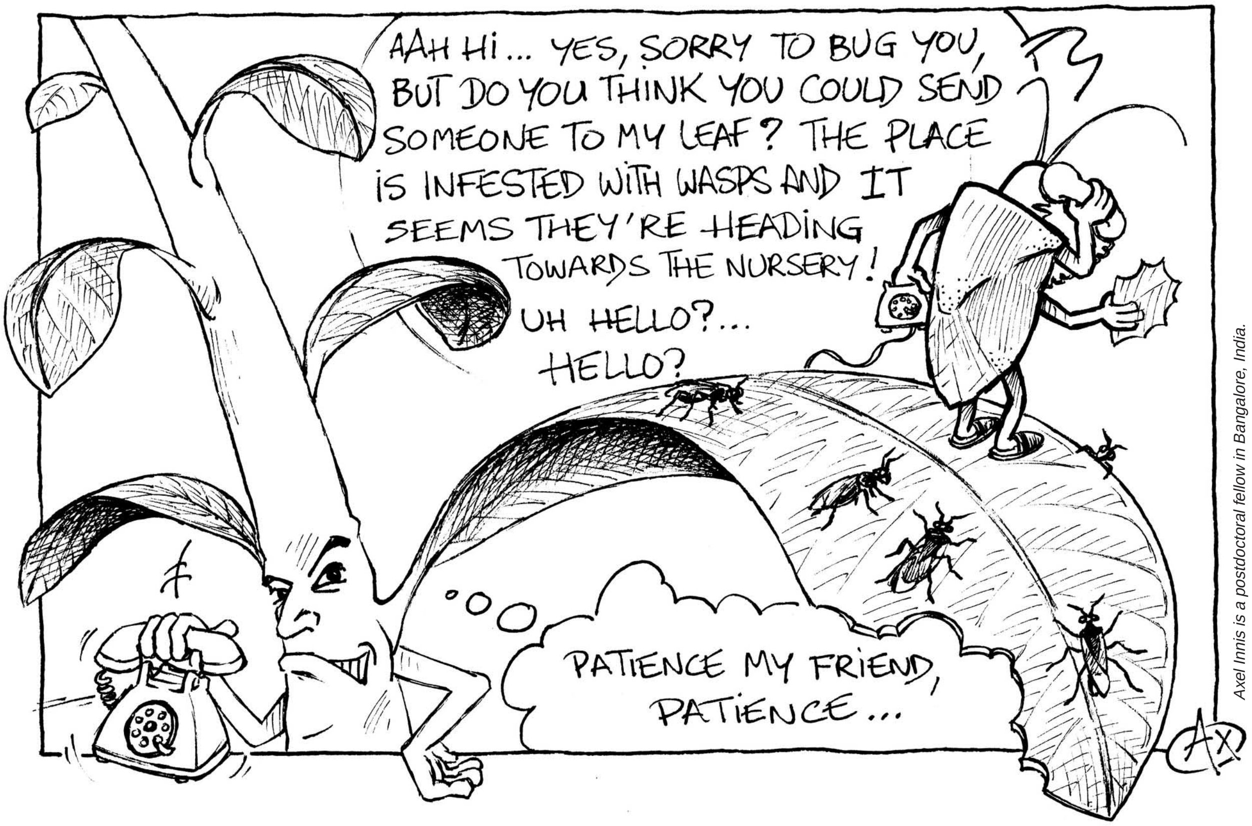
But what happens to the flies when they are allowed to direct their own visual world? Frye simulated the insects moving sideways. He expanded the view to the left and contracted the view to the right, and then allowed the flies to direct the sequence by analysing the insects' wing beats as they tried to manoeuvre. Surprisingly, the flies turned their view of the world to fly towards the contracting image. Frye was astonished, it was as if the insects were flying backwards to avoid a collision! 'Expansion avoidance is so strong' says Frye, 'that it may override other visual behaviours'.

So why do flies chose to behave in such a bizarre fashion? 'It could be a mechanism for flying up wind' explains Frye. When a fly is caught in a strong gust, it might be carried backwards as it struggles against the flow, so all its visual cues tell it that it's going backwards, even when it's making headway.

10.1242/jeb.00780

Tammero, L. F., Frye, M. A. and Dickinson, M. H. (2004). Spatial organization of visuomotor reflexes in *Drosophila*. *J. Exp. Biol.* **207**, 113-122.

WASPS NIP PESTS IN THE BUD



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For most pests, plants are just sitting targets. But while adult insects graze on their victims, some plants have fought back, entering into a pact with their pest's deadliest enemy; the plants attract parasites to prey on the adults and destroy the infestation. But if it's the younger generation of pests that does the most damage after hatching, there's no point in responding to plant alarms raised by feeding parents; the parasite must somehow reveal the location of the pest's eggs to preying parasites. Stefano Colazza and his colleagues in Italy have been analysing stinkbug eggs and broadbean leaves, to find out how they attract parasitic wasps and vanquish the pest (p. 47).

First the team monitored the wasp's responses to damaged legume leaves; the wasps ignored them. But it was a different matter when the broad bean leaves already carried the pest's eggs before adult stinkbugs sucked on the sap. The parasite quickly homed in on the attractive smell, directing them to a clutch of stinkbug eggs ready to wipe out the youngsters before they had a chance to hatch. Colazza explains that annual plants, which have a short life cycle, benefit from eggtargeted parasitoid activity by nipping the pests in the bud.

10.1242/jeb.00782

Colazza, S., Fucarino, A., Peri, E., Salerno, G., Conti, E. and Bin, F. (2004). Insect oviposition induces volatile emission in herbaceous plants that attracts egg parasitoids. *J. Exp. Biol.* **207**, 47-53.

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